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Kato et al.

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[45] **Date of Patent: *Nov. 30, 1999**

[54] **MOVABLE WINDOW**

[75] Inventors: **Yoshifumi Kato**; **Akiteru Nishio**, both of Kariya, Japan

[73] Assignee: **Kabushiki Kaisha Toyoda Jidoshokki Seisakusho**, Aichi ken, Japan

[*] Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

[21] Appl. No.: **08/738,474**

[22] Filed: **Oct. 28, 1996**

[30] **Foreign Application Priority Data**

Oct. 30, 1995 [JP] Japan 7-306748

[51] **Int. Cl.**[6] **B60J 7/00**

[52] **U.S. Cl.** **296/216.09**; 49/482.1

[58] **Field of Search** 296/216; 52/204.597; 49/482.1, 490.1, 493.1

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Primary Examiner—Dennis H. Pedder
Attorney, Agent, or Firm—Morgan & Finnegan, L.L.P.

[57] **ABSTRACT**

A sliding window slidably fitted in an opening of an automobile roof. A frame made of a hard material, which linear expansion coefficient is substantially equal to that of the vehicle body, is fit into the opening. A hard synthetic resin plate is fit into the frame with a flexible molding arranged therebetween. The molding has a thin section which absorbs deformation of the resin plate caused by changes in the temperature.

13 Claims, 6 Drawing Sheets

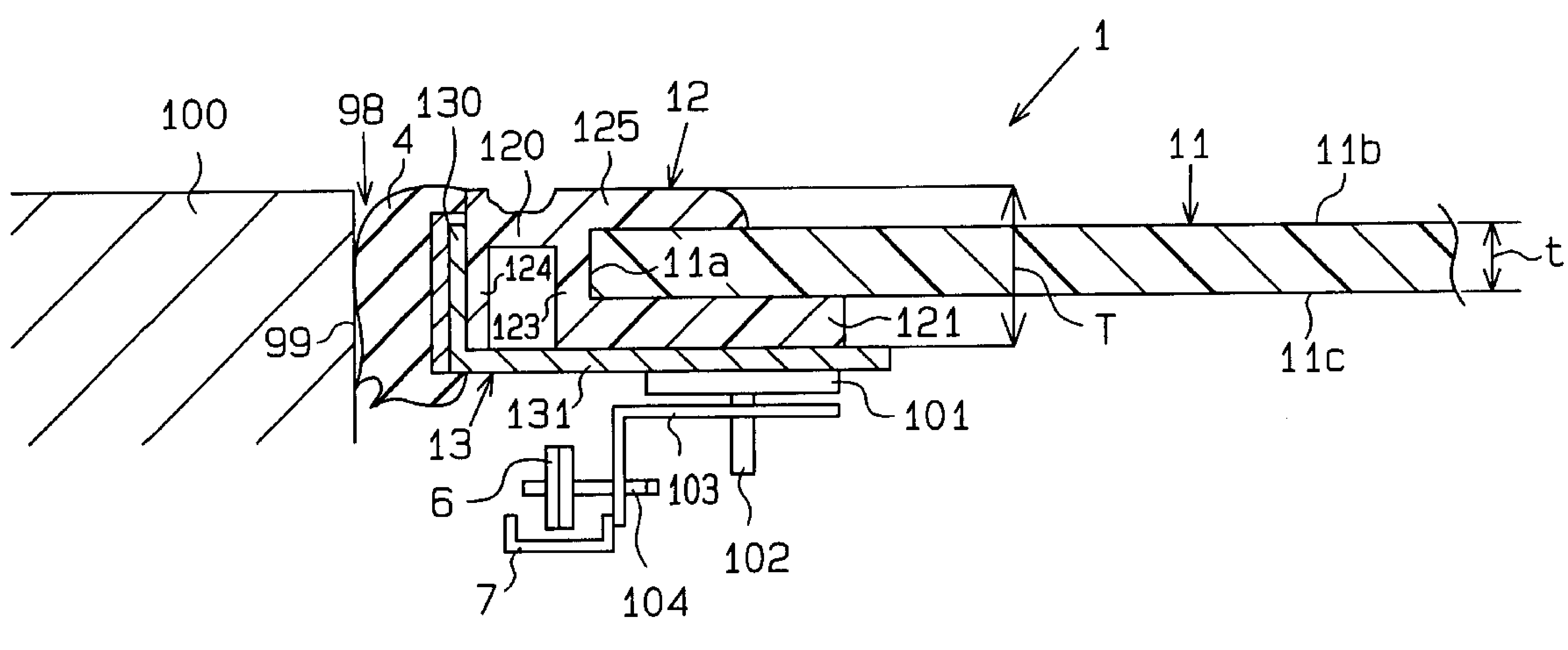
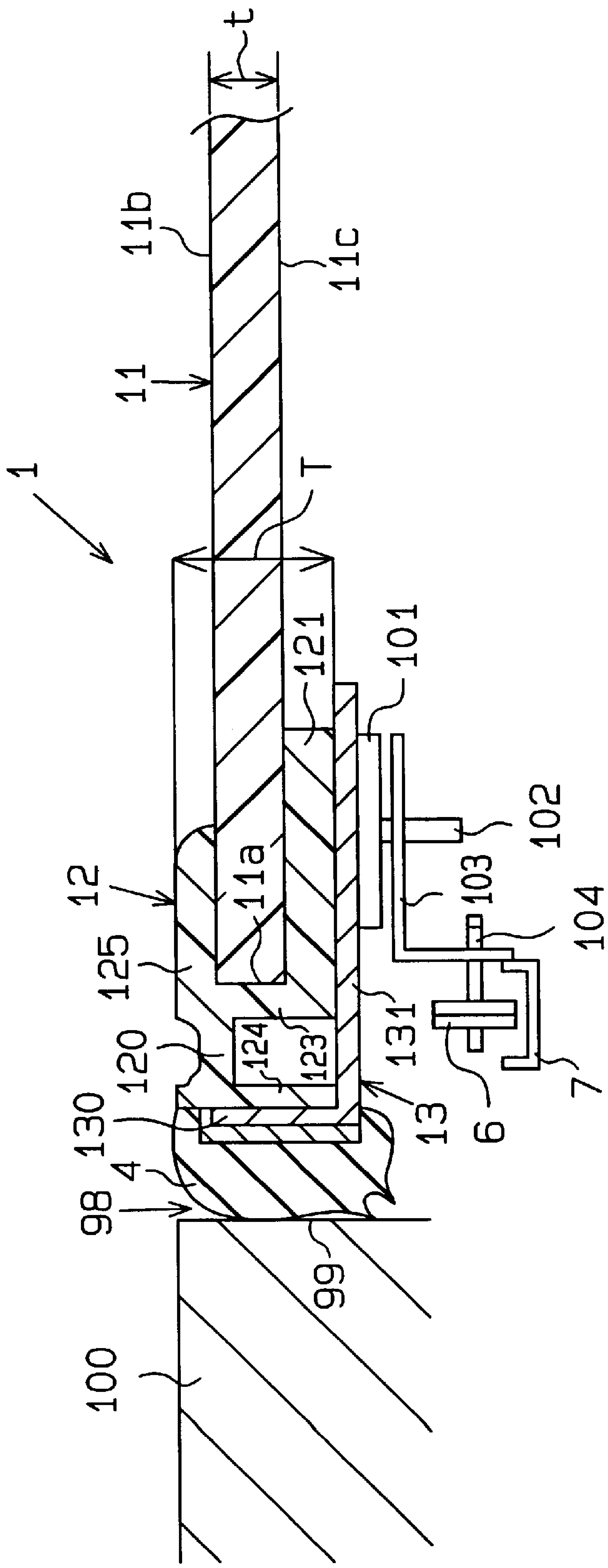


Fig.1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11b
11c
11
1
T
121
101
102
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11a
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131
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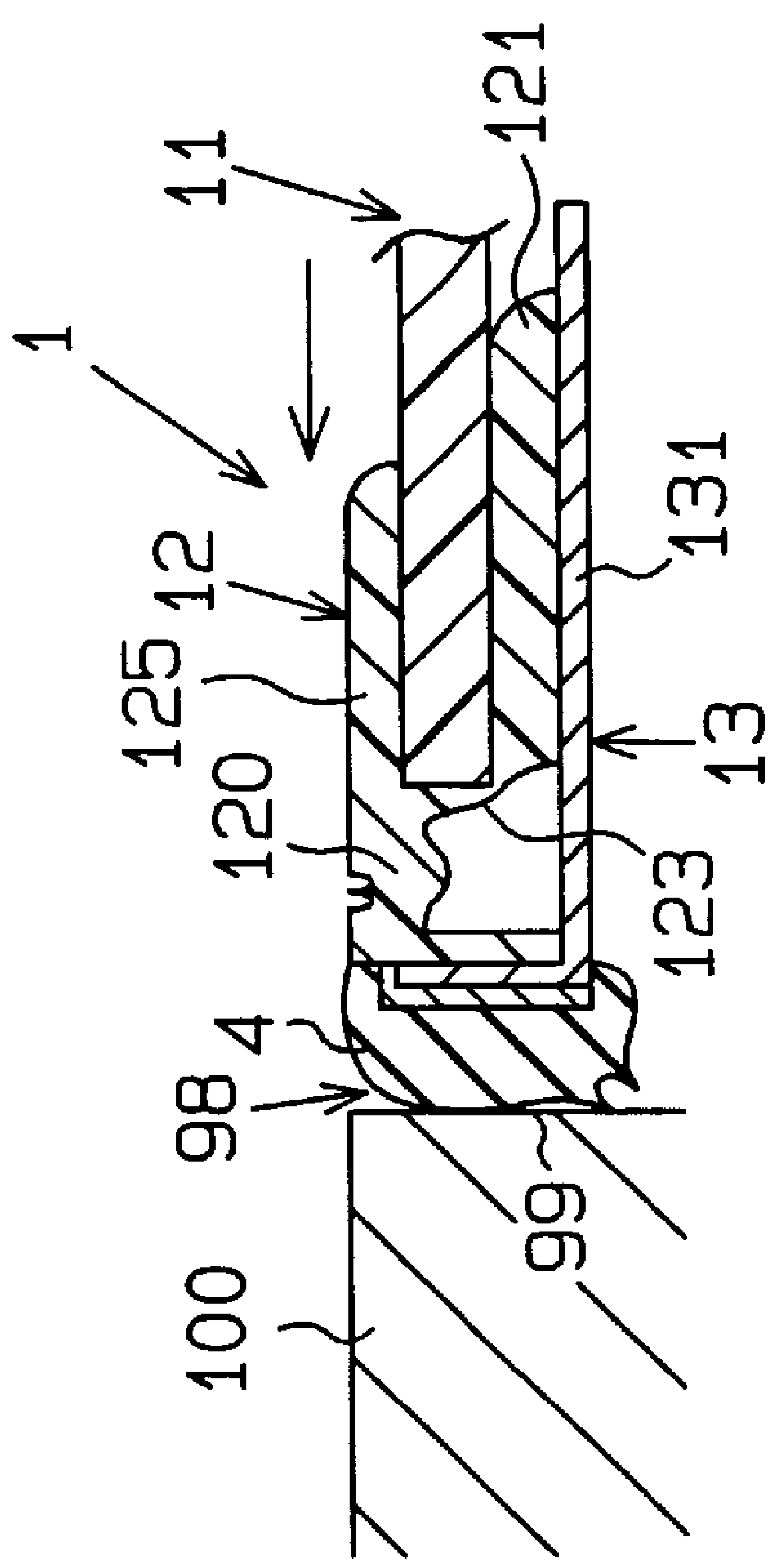
4
98
99
100

Fig. 3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4
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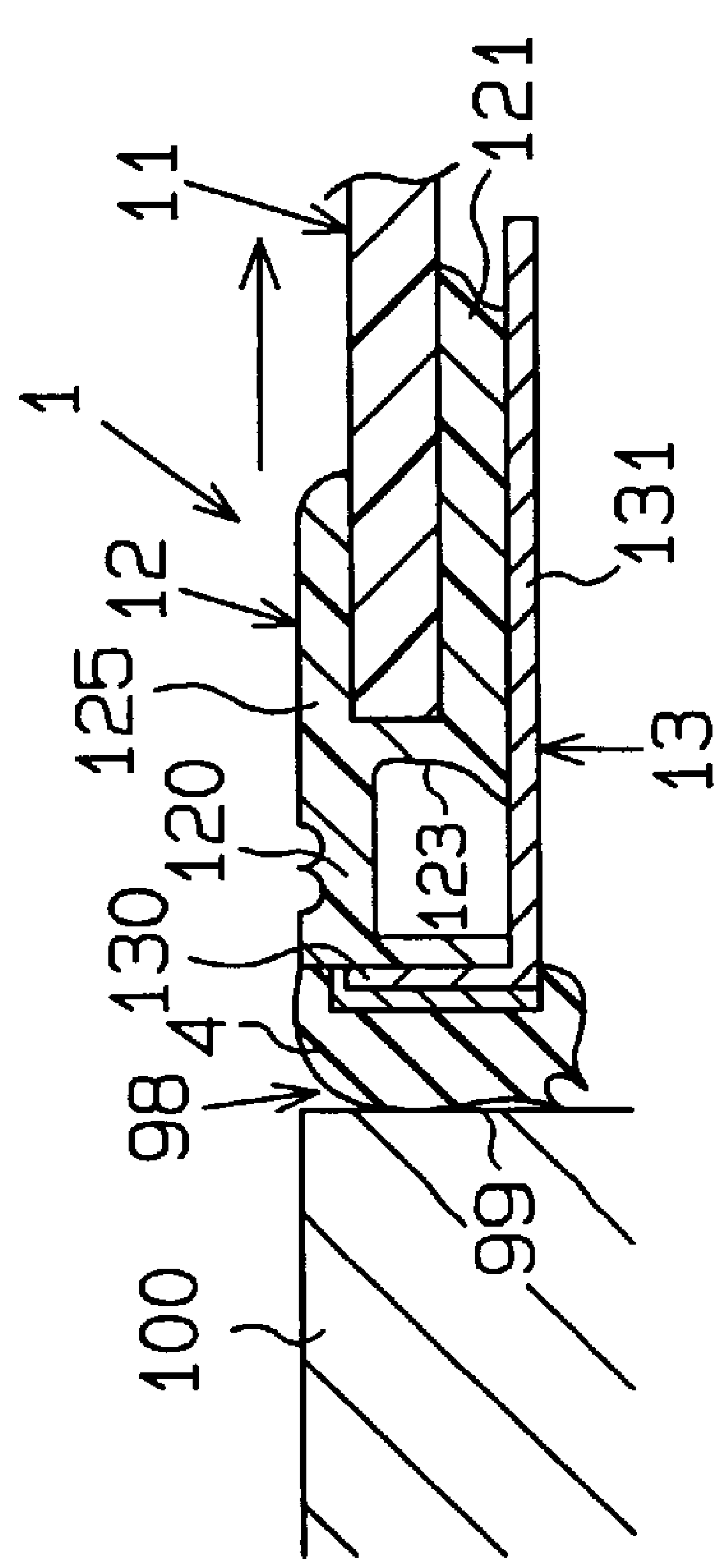
131
13
123

Fig. 2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130
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131
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Fig.5

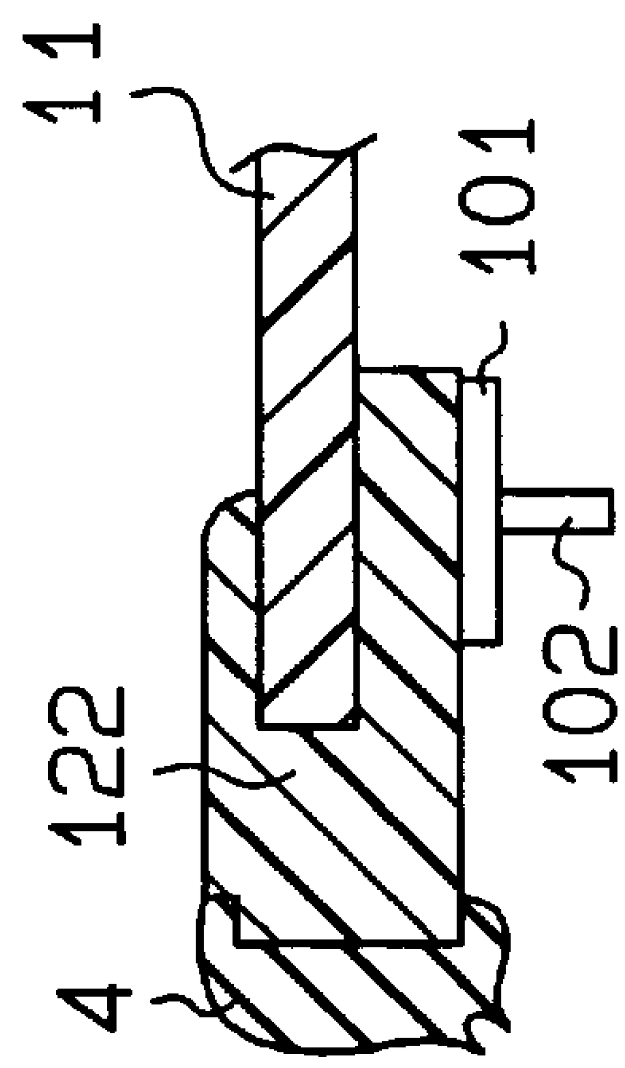


Fig.4

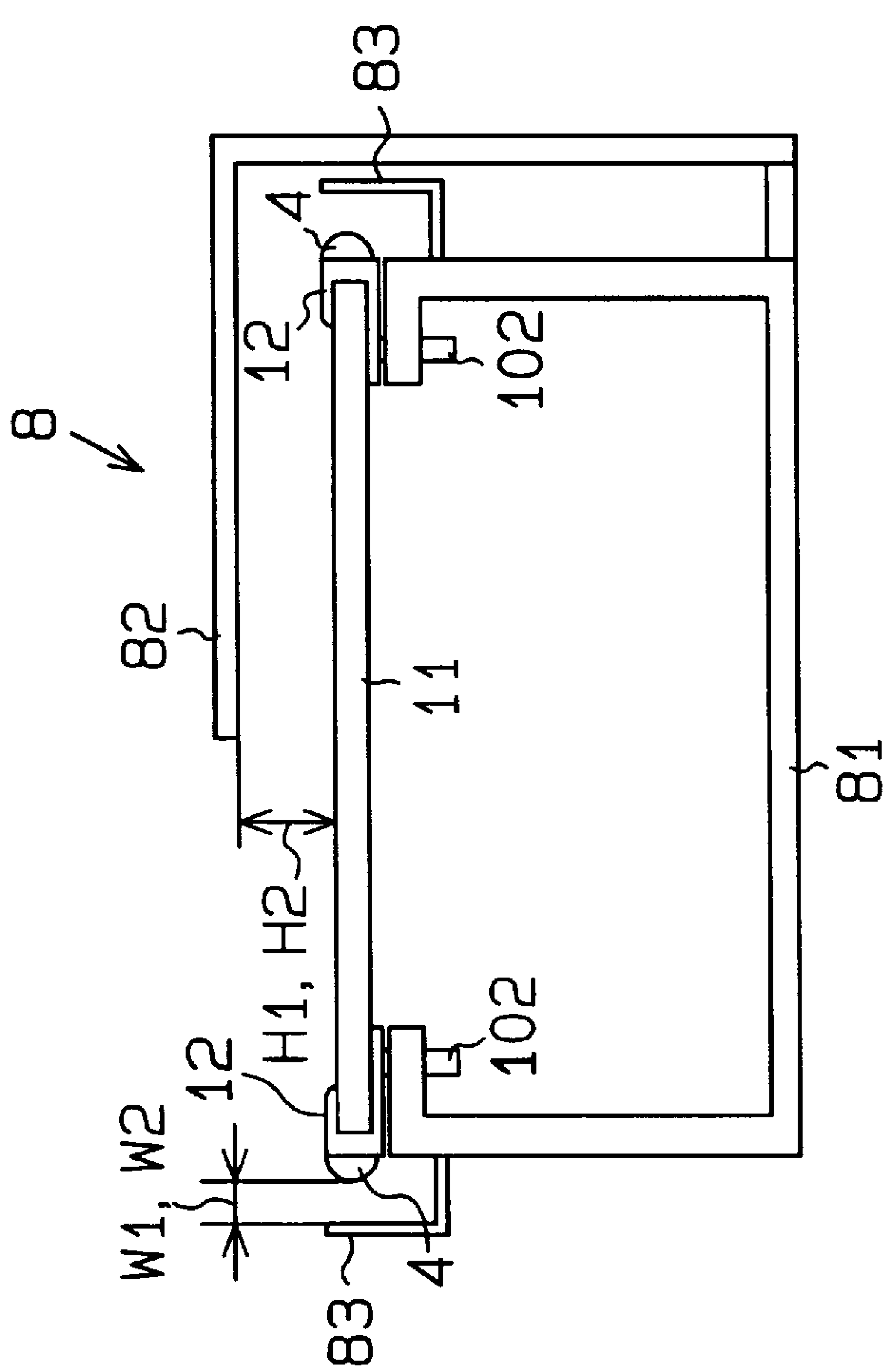


Fig.6

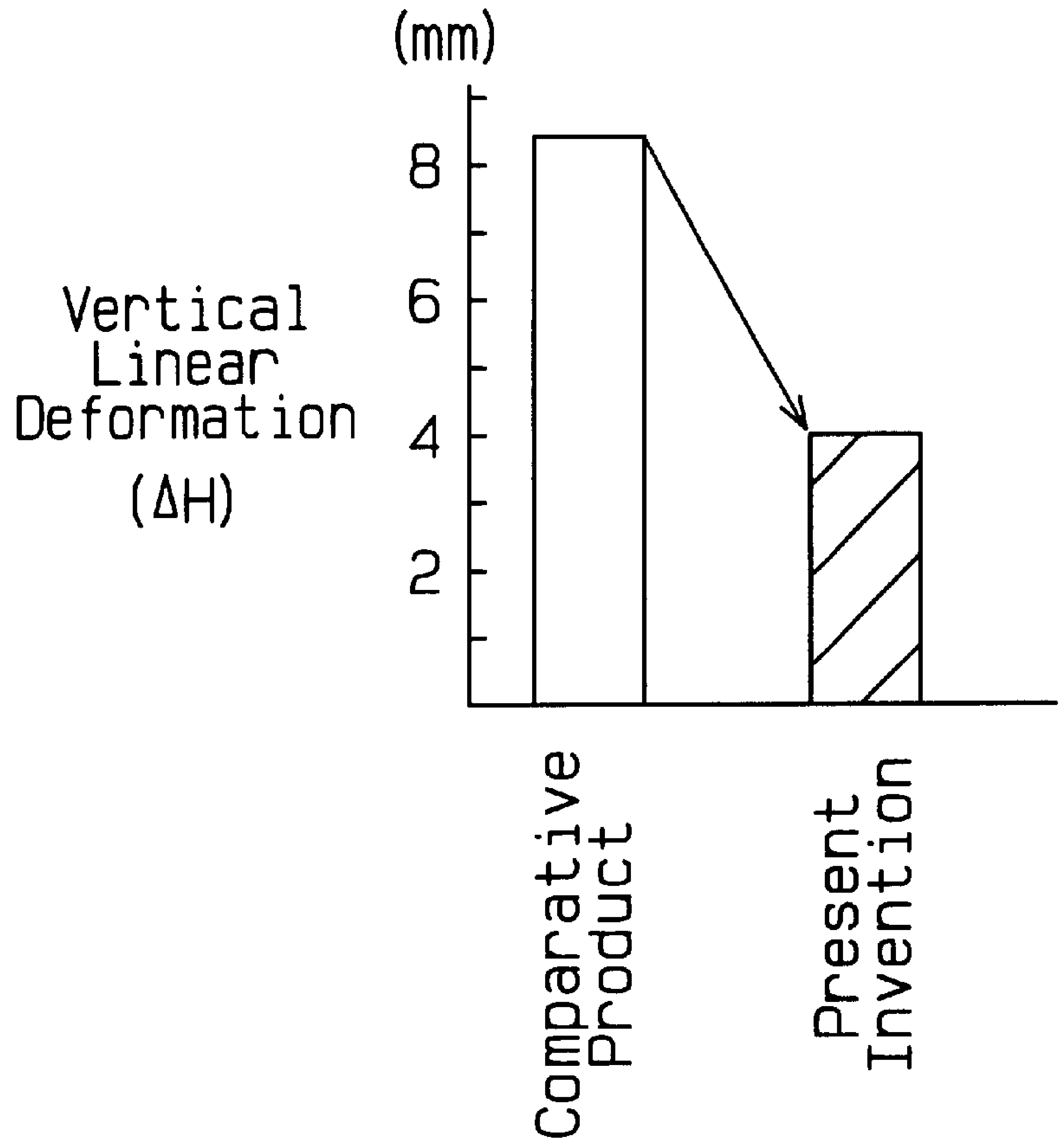
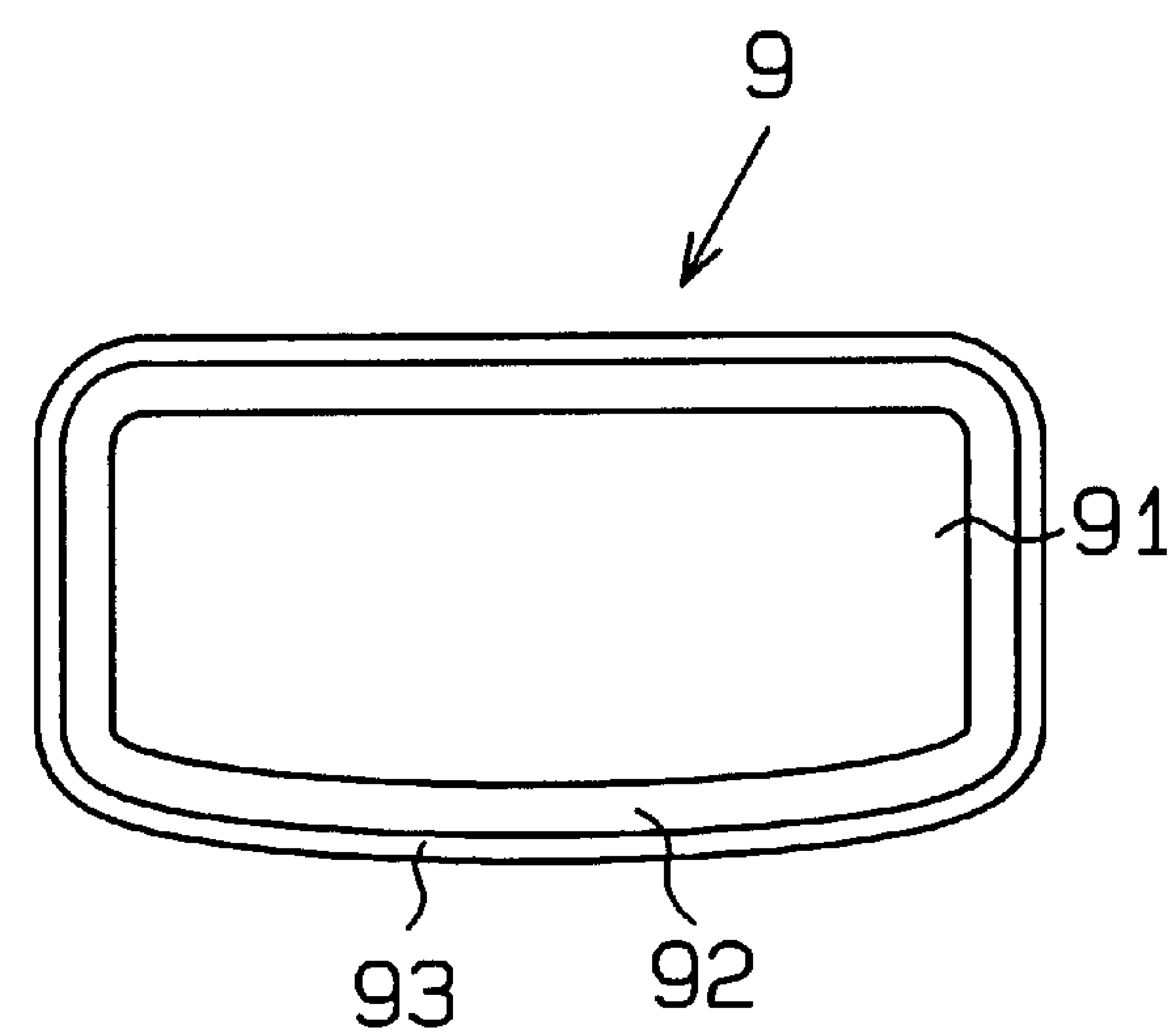


Fig.7
PRIOR ART



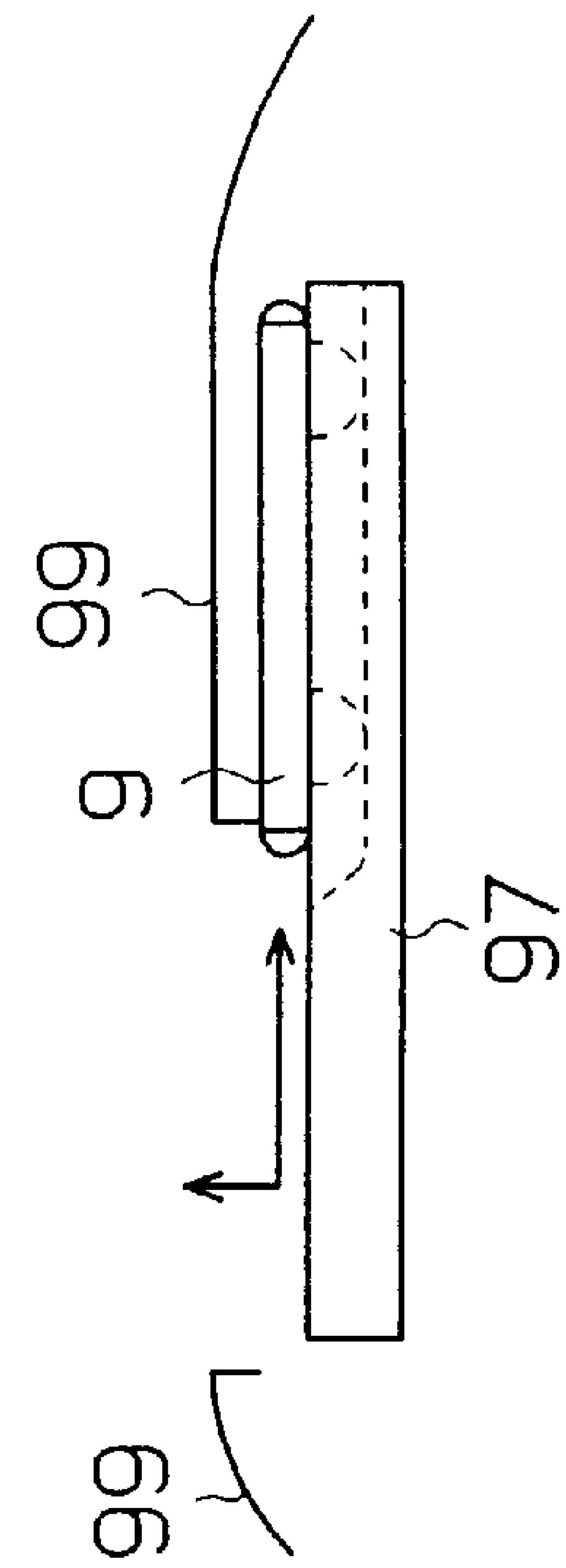


Fig.8(b) Prior Art

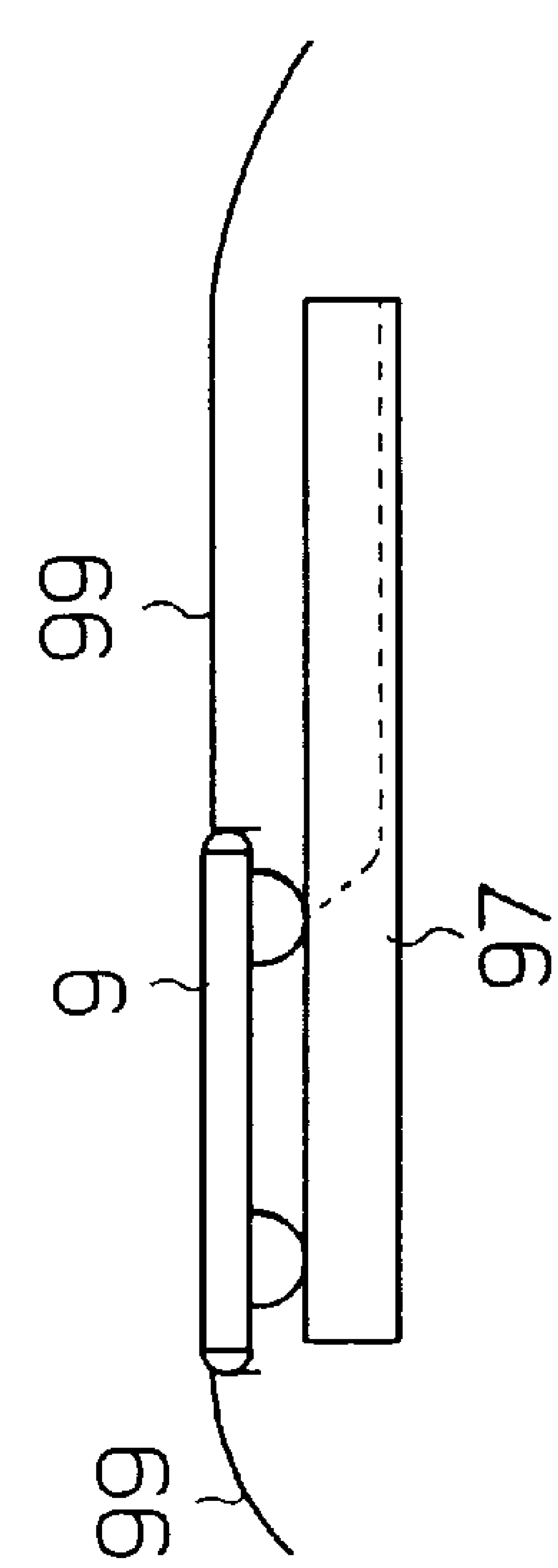


Fig.8(a) Prior Art

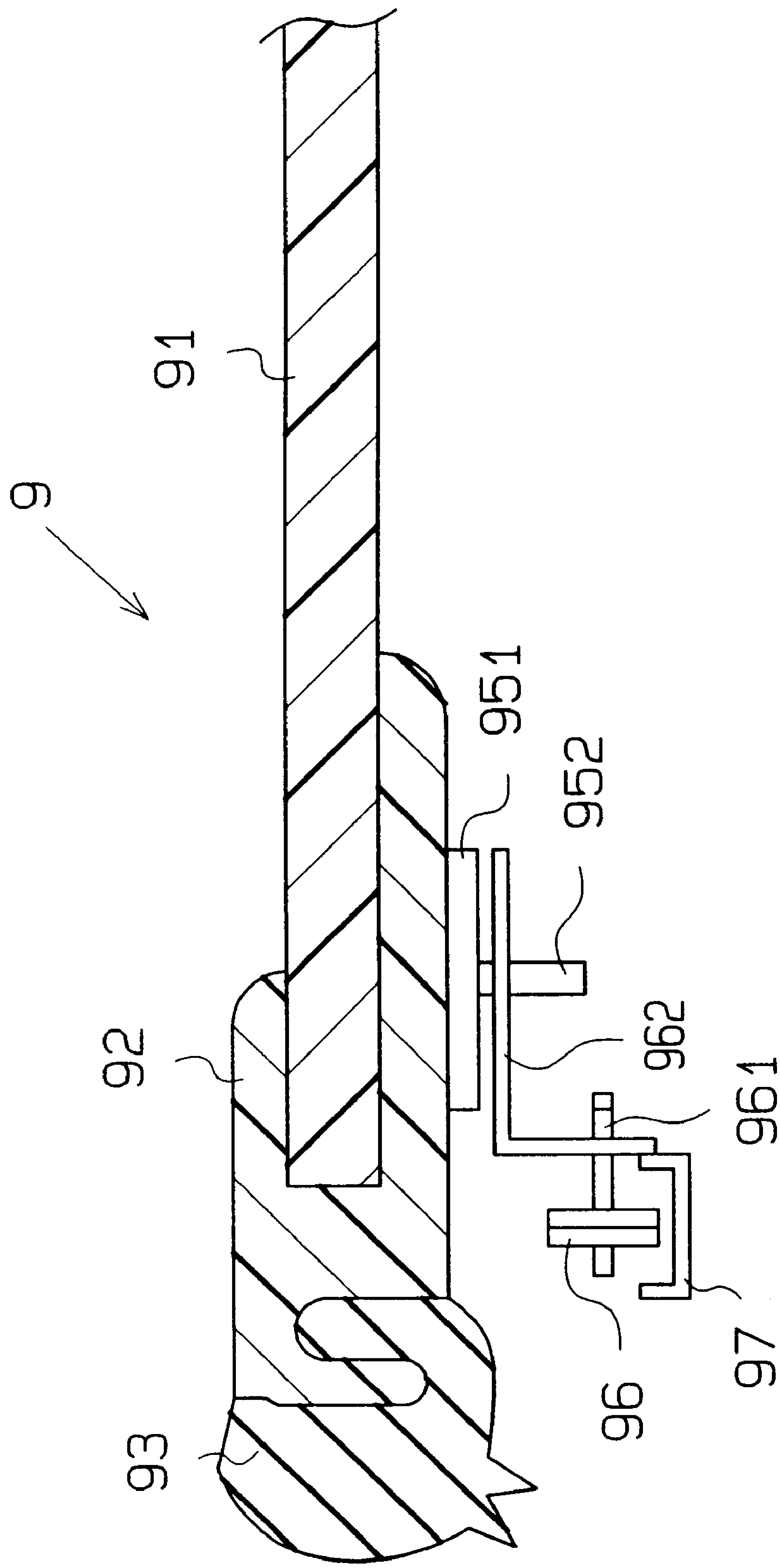


Fig.9
Prior Art

MOVABLE WINDOW

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to sliding windows, and more particularly to sliding windows that are made of a synthetic resin and provided in vehicle roofs.

2. Description of the Related Art

A roof of an automobile may be provided with a sliding window. The window is opened to draw fresh air into the passenger compartment. A typical sliding window **9** is illustrated in FIG. **7**. As shown in FIG. **8**(*a*), the window **9** is fit into an opening in the roof **99** of a vehicle. The window **9** may be lowered with respect to the roof **99** and then moved along a pair of guide rails **97** to open the roof **99**, as shown in FIG. **8**(*b*).

As shown in FIGS. **7** and **9**, the window **9** includes an inorganic glass **91**, a molding **92**, and a weather strip **93**. The molding **92** encompasses the glass **91**. The weather strip **93** encompasses the outer side of the molding **92** to seal the space between the window **9** and the roof **99**. The molding **92** is made of a relatively hard resin while the weather strip **93** is made of a soft rubber.

As shown in FIG. **9**, a washer **951** and a fastener **952** is attached to the bottom surface of the molding **92** near each side of the glass **91**. An elbow-like bracket **962** is held by the fastener **952**. A shaft **961**, which supports a roller **96**, is coupled to the bracket **962**. The roller **96** rolls along the rail **97**. This simple sliding structure enables opening and closing of the window **9**.

During recent years, it has become preferable to use a transparent synthetic resin plate for the sliding window instead of the inorganic glass. A resin plate is lighter and has a better appearance than inorganic glass. When employing a resin plate, it is preferable that major changes are not required in the above sliding structure. In other words, it is preferable that a sliding window employing a resin plate have the same highly reliable structure as the prior art sliding window in which the structure enables sealing of the space between the window and the roof and also enables opening and closing of the window.

However, the linear expansion coefficient of a synthetic resin is greater than that of an inorganic glass. When the vehicle travels, the outdoor temperature causes expansion or contraction of the resin plate. The deformation of the glass results in degradation of the sealing ability between the sliding window **9** and the roof **99**. This may degrade the comfortable environment in the passenger compartment.

SUMMARY OF THE INVENTION

Accordingly, it is an objective of the present invention to provide a sliding window that is light, has a superior appearance, and is highly reliable.

To achieve the above objective, an improved sliding window for a roof of a vehicle is provided. The window has a frame that is fitted to the opening. The frame is made of a hard material having a linear expansion coefficient substantially equal to that of the vehicle body. A hard resin plate is fitted to the frame. A soft molding is interposed between the plate and the frame. The molding has a flexible portion to absorb expansion and contraction deformations of the plate based on changes of temperature.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of the present invention that are believed to be novel are set forth with particularity in the appended claims. The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

FIG. **1** is a cross-sectional view schematically showing the structure of a sliding window according to a first embodiment of the present invention;

FIG. **2** is a cross-sectional view schematically showing the sliding window in a low-temperature state;

FIG. **3** is a cross-sectional view schematically showing the sliding window in a high-temperature state;

FIG. **4** is a schematic view showing a testing fixture;

FIG. **5** is a cross-sectional view schematically showing the structure of a comparative product;

FIG. **6** is a graph illustrating vertical deformation;

FIG. **7** is a plan view showing a prior art sliding window;

FIG. **8**(*a*) is a diagrammatic drawing illustrating the prior art sliding window in a closed state;

FIG. **8**(*b*) is a diagrammatic drawing illustrating the prior art sliding window in an opened state; and

FIG. **9** is a cross-sectional view schematically showing the structure of a prior art sliding window.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A first embodiment of a resin sliding window according to the present invention will hereafter be described with reference to FIGS. **1** to **6**.

As shown in FIGS. **1** to **3**, a sliding window **1** includes a transparent synthetic resin plate **11**, a molding **12** arranged peripherally encompassing the plate **11**, and a frame **13** arranged peripherally encompassing the molding **12**. The sliding window **1** is provided in an opening **98** of a vehicle body outer surface, such as a roof **100** of an automobile which opening **98** has defining peripheral edges **99**. The plate **11** has peripheral edges **11***a*, an outer surface **11***b*, and an inner surface **11***c*. The plate thickness is indicated by the letter t.

In this embodiment, the resin plate **11** is made of a transparent polycarbonate (PC) resin and formed through injection molding. However, the material of the resin plate **11** is not limited to PC. Other transparent resins such as polymethylmethacrylate (PMMA) may also be employed as the material of the plate **11**. If the transparency of sliding panel is not required, resins that are not transparent may also be used as the material of the plate **11**.

In this embodiment, the molding **12** is made of flexible polyvinyl chloride (PVC) and is insert molded around the plate **11**. However, the material of the molding **12** is not limited to PVC. Other flexible resin or rubber materials such as ethylene-propylene-diene terpolymer (EPDM) or olefin thermoplastic elastomer (TPO) may also be used. It is preferable that the rubber hardness of the molding **12** be within the range of 20 to 80. The rubber hardness of PVC employed in this embodiment is approximately 40.

The molding **12** has a thickness T. A thin flexible section **120** is defined in the molding **12**. The thickness of the thin section **120** is less than the thickness T of the molding **12**. The molding **12** also has a second flexible section **121**, a plate edge attachment section **123**, a frame attachment section **124**, and a plate upper surface attachment section **125**. All of sections **120**, **121**, **123**–**125** are integrally formed with each other as by molding.

In this embodiment, the frame **13** is made of sheet moulding compound (SMC), which is a reinforced plastic. The linear expansion coefficient of SMC is almost the same as that of steel. That is, the linear expansion coefficient of the frame **13**, which is 1.8×10^{-5}cm/cm/° C., is slightly greater than that of steel (1.17×10^{-5}cm/cm/° C.) but much smaller than that of the resin plate **11** (PC, 7×10^{-5}cm/cm/° C.).

The material of the frame **13** is not limited to SMC. However, it is preferable that the frame **13** have a linear expansion coefficient of 1.8×10^{-5}cm/cm/° C. or less and be made of a material selected from a group consisting of steel, aluminum, reinforced plastic, or the like. This sufficiently satisfies the requirements of the linear expansion coefficient relationship described above. Reinforced plastics such as bulk molding compound (BMC) and fiber reinforced plastic (FRP) may be used as the material of the frame **13**.

As shown in FIG. **1**, the frame **13** has an L-shaped cross-section, providing a first leg portion **130** parallel to, but spaced peripherally outward from the peripheral edges **11***a* of the plate **11**, and a bottom leg portion **131** integral with, and extending peripherally inward from the first leg portion **130** in underlapping relation with, but spaced away from the inner surface **11***c* of plate **11**, as seen in FIGS. **1**, **2** and **3**. The molding sections **121** and **124** are attached by adhesive securement to all of the respective edges and surfaces of the frame **13** with which they are respectively in contact and the molding sections **121**, **123**, and **125** are adhered, by insert molding, to the respective surfaces of the plate **11** with which they contact. This enables the inner walls, outer walls, and bottom of the frame **13** to be effectively used. The molding **12** is adhered to the frame **13** by a butyl adhering agent. As shown in FIG. **1**, a weather strip **4** is adhered around the frame **13**. The weather strip **4** may also be formed integrally with and from the same material as the molding **12**. In the same manner as the prior art, a washer **101** and a fastener **102** are attached to the bottom surface of the frame **13**. A bracket **103** is held by the fastener **102**. A shaft **104**, which supports a roller **6**, is coupled to the bracket **103**. The roller **6** rolls along a guide rail **7** and enables the sliding window **1** to move with respect to the rail **7**.

The sliding window **1** according to the present invention is provided with the resin plate peripherally **11** encompassed by the molding **12** in the frame **13**. Accordingly, the dimensions of the sliding window **1** are determined by the dimensions of the frame **13**. In addition, the molding **12** is provided with the thin section **120** located between the resin plate **11** and the frame **13**. The thin section **120** is flexible in comparison with other parts of the molding **12**. Therefore, the thin section **120** expands when low temperature causes contraction of the plate **11** as shown in FIG. **2**. The contraction of the plate **11** is absorbed by the thin section **120**. The thin section **120** contracts when high temperature causes expansion of the plate **11** as shown in FIG. **3**. The expansion of the plate **11** is absorbed by the thin section **120**. Accordingly, the thin section **120** of the molding **12** prevents changes in the dimensions of the frame **13** when the plate **11** is deformed by different temperatures. This, in turn, prevents deformation of the entire sliding window **1**. As also illustrated in FIGS. **2** and **3**, the second flexible section **121** of the molding **12** also flexes in response to the temperature-induced expansions and contractions of the plate **11**, to permit the required movement in peripherally outward and inward directions with respect to the frame bottom leg portion **131**, while maintaining the attachment between the plate **11** and frame **13**.

The linear expansion coefficient of the frame **13** is almost the same as that of steel. Thus, the difference between the linear expansion coefficient of the frame **13** and that of the steel vehicle body including the roof **100** is small. Accordingly, the space defined between the periphery of the sliding window **1** and the roof **100**, where the window **1** is fit into, remains substantially the same regardless of changes in the temperature. In addition, the space between the sliding window **1** and the roof **100** is kept sealed by the weather strip **4**.

The vertical and lateral linear deformation of the sliding window **1** was measured by a testing fixture **8** illustrated in FIG. **4**. A thermoplastic elastomer (RABALON, registered trademark of Mitsubishi Kagaku Kabushiki Kaisha) was used for the molding **12**.

The vertical and lateral linear deformation of a comparative (prior art) product was also measured to compare data. The comparative product employed the same resin plate **11** as the sliding window **1** according to the present invention. Thus, each plate **11** is made of the same material. However, as shown in FIG. **5**, a molding **122** of the comparative product is not provided with a thin section and is not peripherally encompassed by a frame. Thus, the molding **122** is directly connected to the weather strip **4**. Polyamide **66**, which is a well-known material, was used as the material of the molding **122**. The remaining structure of the comparative product is the same as the structure of the sliding window **1** of the present invention.

As shown in FIG. **4**, the testing fixture **8** includes a steel setting device **81**, by which the sliding window **1** and the comparative product were held, a vertical reference bar **82**, which indicates a vertical reference point (first reference point), and a lateral reference bar **83**, which indicates a lateral reference point (second reference point). The sliding window that was to be tested was set on the setting device **81** so as to simulate conditions during actual usage.

The fasteners **102** of each sliding window were fixed to the setting device **81** when vertical linear deformation was measured and slidably connected to the device when linear lateral deformation was measured.

After each sliding window was set on the setting device **81**, the vertical distance H1 between the first reference point and the sliding window and the lateral distance W1 between the second reference point and the sliding window was measured at room temperature (18 degrees Celsius). The vertical distance H2 between the first reference point and the sliding window and the lateral distance W2 between the second reference point and the sliding window was then measured at a high temperature (90 degrees Celsius). The vertical and lateral linear deformations ΔH, ΔW obtained from the difference between the two temperature conditions were calculated as follows:

$$H2-H1=\Delta H, W2-W1=\Delta W$$

FIG. **6** illustrates the results of the vertical linear deformation ΔH (mm). The lateral axis shows the measured subject while the vertical axis shows the vertical linear deformation ΔH. It is evident from the graph that the vertical deformation of the sliding window according to the present invention was about half of that of the comparative product.

From this result, it may be understood that providing a thin section in the molding and using a flexible material for the molding sufficiently reduces vertical deformation.

The lateral deformation ΔW of the sliding window according to the present invention was 0.3 mm while the lateral deformation ΔW of the comparative product was 1.2 mm. From this result, it is apparent that the lateral linear deformation ΔW of the sliding window according to the present invention was drastically reduced in comparison with the comparative product representing the prior art sliding window.

It is apparent that the molding **12**, which is made of a flexible material and is provided with the thin section **120**, absorbs the deformation of the resin plate **2**. In addition, the employment of a frame having a low linear expansion coefficient sufficiently suppresses deformation of the sliding window **1**.

The effects of the hardness of the molding **12** employed in the sliding window of the present invention was also evaluated. As shown in table 1, six types of moldings, each having a different rubber hardness, were evaluated. Among these evaluation products, E**1**, E, E**3** represent the moldings **12** having a satisfactory rubber hardness. The rubber harnesses of E**1**, E**2**, E**3** are 20, 50, 80, respectively. The products outside the satisfactory hardness range are represented by C**2**, C**3**, C**4**. The rubber hardness of C**2** is below 10 while that of C**3** is 100. The rubber hardness of C**4** exceeds 100.

TABLE 1

Evaluation Product	C2	E1	E2	E3	C3	C4
Rubber Hardness	Below 10	20	50	80	100	Over 100
Moldability	Δ	O	O	O	O	O
Strength	Δ	O	O	O	O	O
Absorption Effect	O	O	O	O	Δ	X

The evaluated items were moldability, strength, and absorption effect. Moldability was evaluated by judging the efficiency when filling a mold to insert-mold the molding **12** about the resin plate **11** and by judging how simple it was to release the mold after completion of the molding. Strength was evaluated by judging whether damage was inflicted on the molding **12** or whether the molding **12** fell off from the resin plate during actual usage of the sliding window. Absorption effect was evaluated by judging whether the thin section **120** of the molding **12** effectively absorbed the expansion and contraction of the glass. Each molding **12** was evaluated as good(○), satisfactory(Δ), and poor(X).

As evident from table 1, the moldability and strength of the molding becomes slightly inferior when the rubber hardness is lower than 10. The absorption effect of the molding **12** is lowered when the rubber hardness is 100 or greater. Accordingly, the advantages of the present invention are further ensured by maintaining the rubber hardness of the molding within the range of 20 to 80.

Although only one embodiment of the present invention has been described herein, it should be apparent to those skilled in the art that the present invention may be embodied in many other specific forms without departing from the spirit or scope of the invention.

Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein, but may be modified within the scope of the appended claims.

What is claimed is:

1. A panel closing an opening provided within an outer surface of a vehicle body, said opening being defined by peripheral edges within said vehicle body outer surface, said panel comprising:

a plate within said vehicle body opening and having peripheral edges corresponding to, but spaced peripherally inward from respective of said peripheral edges which define said vehicle body opening, said plate having an outer surface on a side corresponding to said outer surface of the vehicle body, and an inner surface opposite to said outer surface, said peripheral edges of said plate extending between said outer and inner surfaces and defining a thickness of the plate,

a peripheral frame having substantially L-shaped cross-section and peripherally surrounding said plate within said vehicle body opening, and further having peripheral edges corresponding to said respective peripheral edges of said plate, said L-shaped frame cross-section including a first leg portion generally parallel to, but spaced peripherally outward from said peripheral edges of the plate, and a bottom leg portion extending peripherally inward from said first leg portion in underlapping relation with, but spaced away from said inner surface of the plate to provide a spacing therebetween, and

a peripherally extending molding comprising a thin flexible section extending between and secured to both of said first leg portion of said frame and said peripheral edges of said plate, said thin flexible section being out of contact with said bottom leg portion of said frame thereby permitting peripherally inward and outward flexing movement of said thin flexible section, and a second flexible section between and secured to both-of said inner surface of said plate and said bottom leg portion of said frame within said spacing therebetween but peripherally spaced away from said first leg portion of the frame thereby permitting peripherally inward and outward flexing movement of the second flexible section,

said peripheral frame and said vehicle body outer surface being of hard materials respectively having linear expansion coefficients which are substantially equal to each other,

said plate being of hard resin material having a higher linear expansion coefficient than said linear expansion coefficients of said frame and said vehicle body outer surface, and

said thin and second flexible sections of said molding being flexible to absorb temperature-induced expansion and contraction deformations of said plate with respect to said frame.

2. A panel according to claim **1** wherein said peripherally extending molding further comprises a plate edge attachment section integral with and extending between said thin flexible section and said second flexible section and secured to and along said peripheral edges of said plate, said plate edge attachment section being peripherally spaced away from said first leg portion of said frame.

3. A panel according to claim **2** wherein said peripherally extending molding further comprises a frame attachment section integral with said thin flexible section and adhesively secured to and along said first leg portion of the frame, said frame attachment section being peripherally spaced away from said plate edge attachment section and said second flexible section.

4. A panel according to claim **1** wherein said thin flexible section of the peripherally extending molding extends peripherally outward in substantial alignment with said outer surface of said plate.

5. A panel according to claim **4** wherein said peripherally extending molding further comprises another flexible attachment section integral with said thin flexible section and said plate edge attachment section, and extending in overlapping relation with, and secured to said outer surface of said plate.

6. A panel according to claim **1**, wherein said frame is made of a material selected from the group consisting of steel, aluminum and reinforced plastic.

7. A panel according to claim **6**, wherein said plate is made of a material selected from the group consisting of polymethylmethacrylate and polycarbonate.

8. A panel according to claim **1**, wherein said molding is made of one of soft rubber and soft resin having a rubber hardness within the range of 20 to 80.

9. A panel according to claim **8**, wherein said molding is made of a material selected from the group consisting of polyvinyl chloride, ethylene-propylene-diene terpolymer, and olefin thermoplastic elastomer.

10. A panel according to claim **1**, wherein said panel is a movable panel for selectively opening and closing said opening within said vehicle outer surface, and which further comprises means on said peripheral frame and means on said vehicle body connected to each other for permitting movement of said panel between respective positions opening and closing said vehicle body opening.

11. A panel according to claim **10**, wherein said vehicle outer surface is a roof of said vehicle, said plate is of transparent resin material, and said means on said peripheral frame and said means on said vehicle body permit sliding movement between said positions, whereby said panel is a sliding window in said roof of the vehicle.

12. A panel according to claim **11**, which further comprises a peripheral weather strip of flexible material secured to said first leg portion of said L-shaped frame and sealingly engaging said peripheral edges of said vehicle body opening when said panel closes said opening.

13. A panel according to claim **12**, wherein said weather strip is joined with said molding.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,992,928
DATED : November 30, 1999
INVENTOR(S) : Yoshifumi Kato et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 2,
Line 38, after "automobile" insert a comma -- , --;
Line 48, after "If" delete "the" and before "sliding" insert -- the --;
Line 52, change "insert molded" to -- insert-molded --.

Column 6,
Line 26, change "both-of" to -- both of --;
Line 54, delete "adhesively";

Signed and Sealed this

Ninth Day of April, 2002

Attest:

JAMES E. ROGAN

Attesting Officer

Director of the United States Patent and Trademark Office